PIXEL STRUCTURE TEST RESULTS

MAY 27, 1999

INNER DETECTOR COOLING REVIEW

SESSION 4

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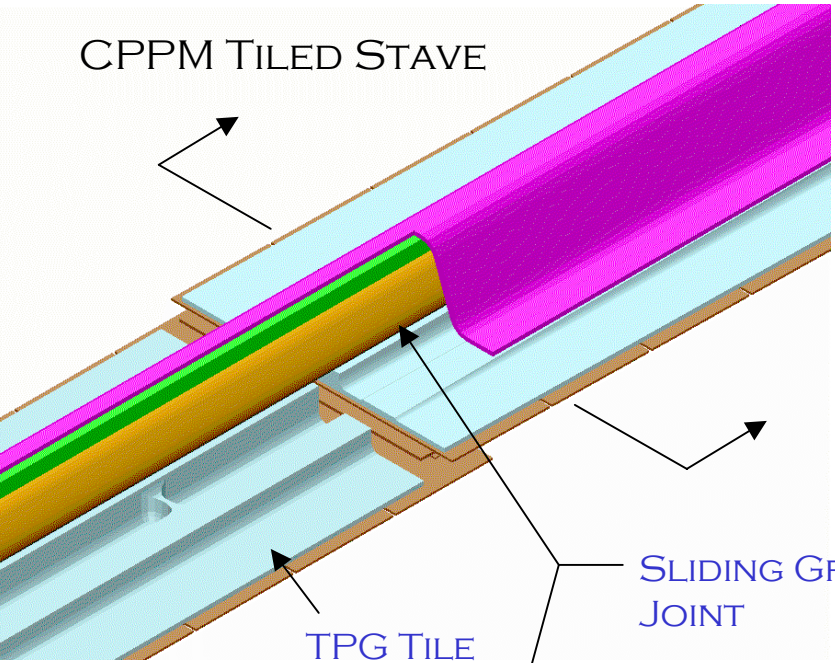
Overview

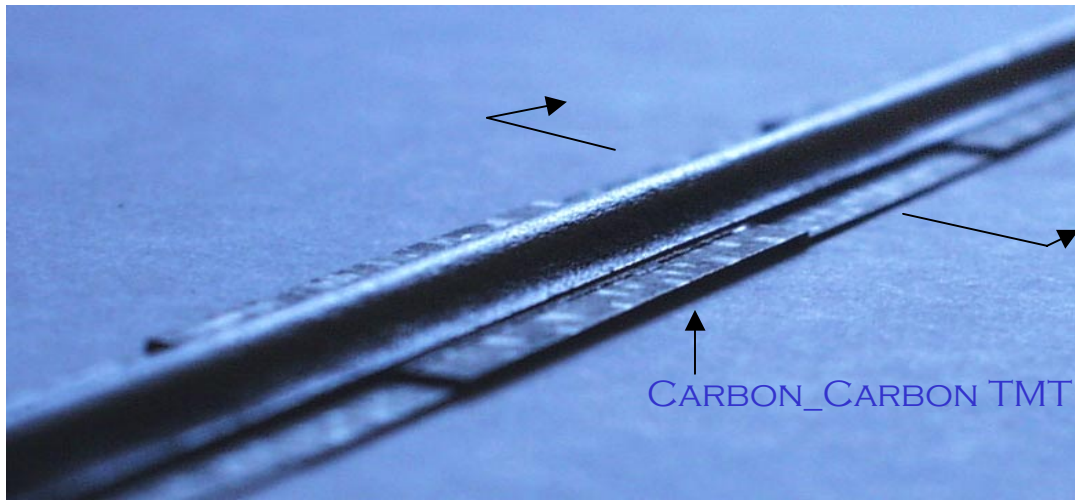
- **Description of various structures which have been tested**
- **Historical measurements for comparison (0.6W/cm^2)**
  - CPPM sliding Aluminum tube stave (evaporative)
  - Oriented sector tests (evaporative)
  - Methanol/Water tests of same/similar structures
- **Measurements at new power density (0.83W/cm^2)**
  - Genova Stepped Stave geometry with silicon
  - ESLI Sector 4(?)
- **Observations**

TDR Power:	Stave: 73.0W Sector: 36.5W	New Power:	Stave: 107W Sector: 49.5W

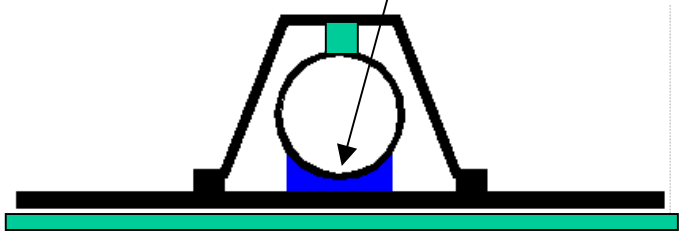
Pixel Detector

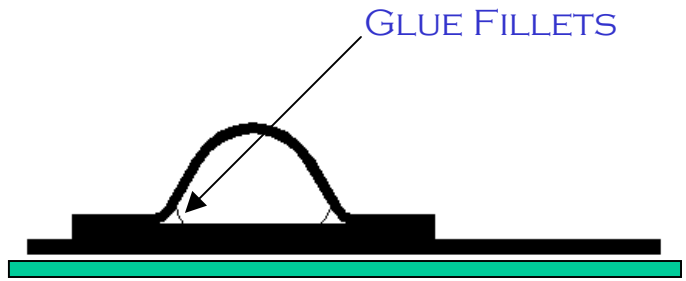
The Staves (Dominant Variations)





Genova Monolithic Stave
(now shingled geometry)





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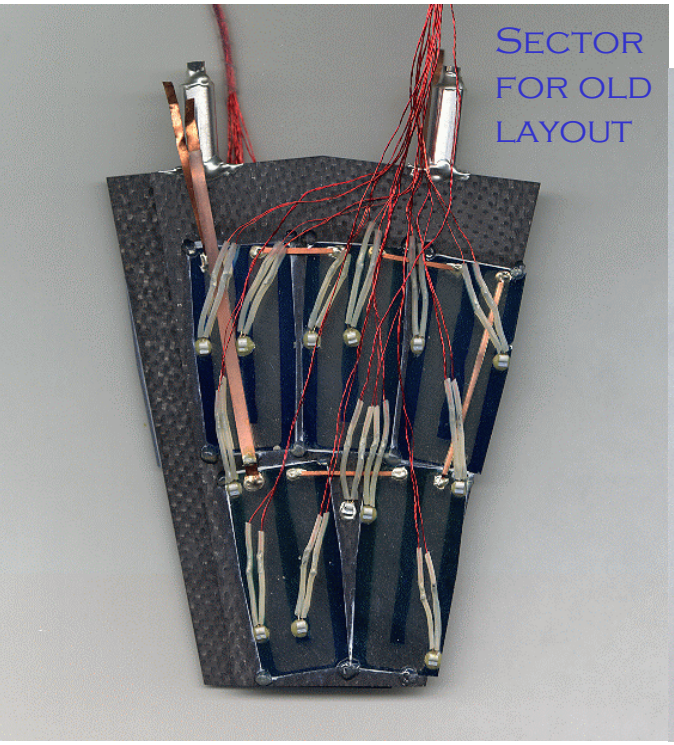
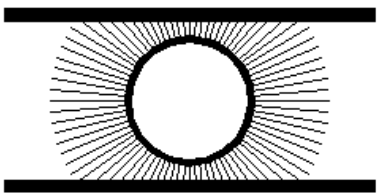
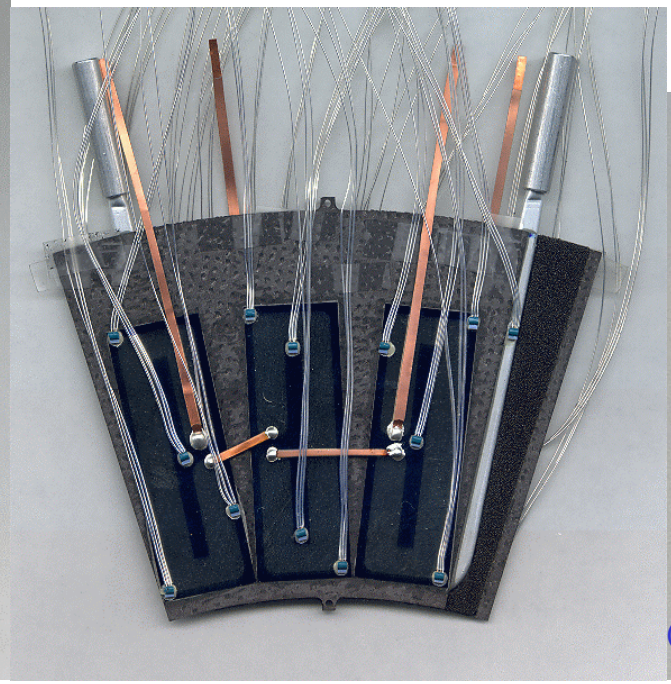
Disks, a Retrospective



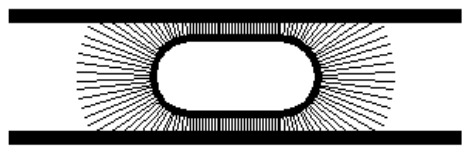
ESLI Sectors 4-7





LBNL Al-Tube 3

ESLI Sectors 8 & 9



Sector designs have converged at ESLI 8/9 and Al-tube 4

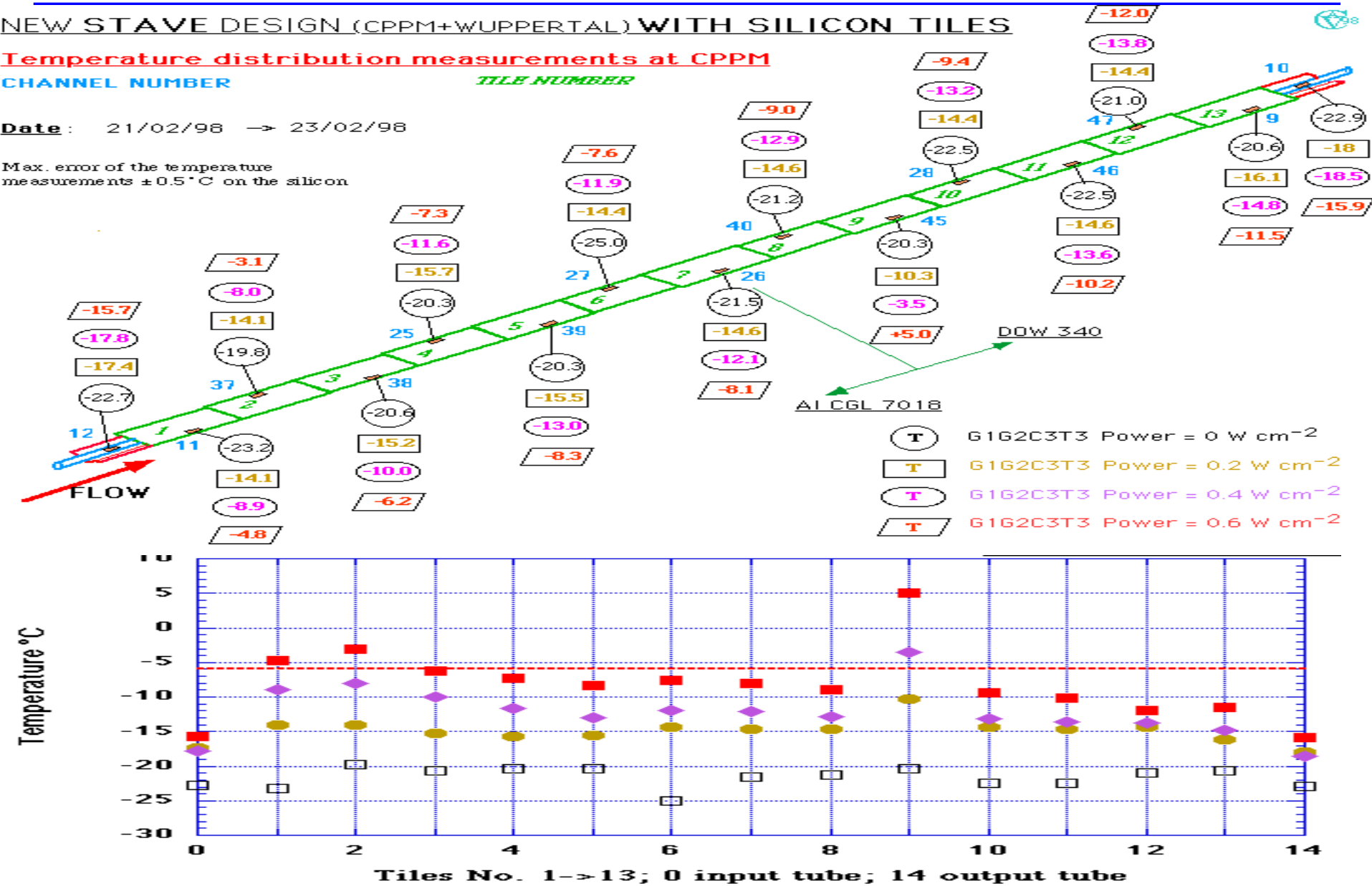
Heaters and Heat loads

- **Heaters have been of two types--Silicon and "Minco"**
  - Silicon heaters have same form factor as module, mounts similarly and is of the same general material--measurements more believable as less extrapolation is necessary
  - Minco Heaters have localized resistive elements embedded in an insulator
  - Heater type not generally recorded with data
- **Measured temperature drop into coolant is affected by heater type and how it is attached**
  - Impedance of heater attachment affects measured temperature
    - Community has narrowed down to a select few thermal compounds and associated properties
  - Heater non-uniformity on level of PT1000 form factor likely for Minco style heaters

Heat Loads

- **Sectors and Stave have approximately the same heat influx per unit length of cooling tube (factoid)**
  - Was ~1W/cm @ 0.6W/cm^2
  - Stave has twice the flux because it comes in from only one side
- **0.6W/cm^2 (TDR Full Power)**
  - Stave power was 72W
  - Sector Power was 36.4W
- **0.83W/cm^2 (Worst Case Estimate)**
  - Stave power 107W
  - Sector power 49.5W

Pixel Detector



Pixel Detector

C4F10 Cooling

p_{exhm}=43 torr
p_{exh}=256 mbar
p_{inj}=1692 mbar
p_{pump}=1.9 bar_{abs}
T_{pump}= -10.1 °C
Amb.= -13.4 °C
Pow.= 40.2 W

p_{exhm}= 34 torr
p_{exh}= 241 mbar
p_{inj}=1591 mbar
p_{pump}=1.85 bar_{abs}
T_{pump}= -9.4 °C
Amb.= -8.5 °C
Pow.= 40 W

p_{exhm}=250 torr
p_{exh}=345 mbar
p_{inj}=1721 mbar
p_{pump}=1.95 bar_{abs}
T_{pump}= -9.5 °C
Amb.= -10.4 °C
Pow.= 39.5 W

p_{exhm}= 40 torr
p_{exh}= 269.5 mbar
p_{inj}= 1885 mbar
p_{pump}= 2.1 bar
T_{pump}= -8.9 °C
Amb.= -12.5 °C
Pow.= 40 W

Sector Feasibility Study

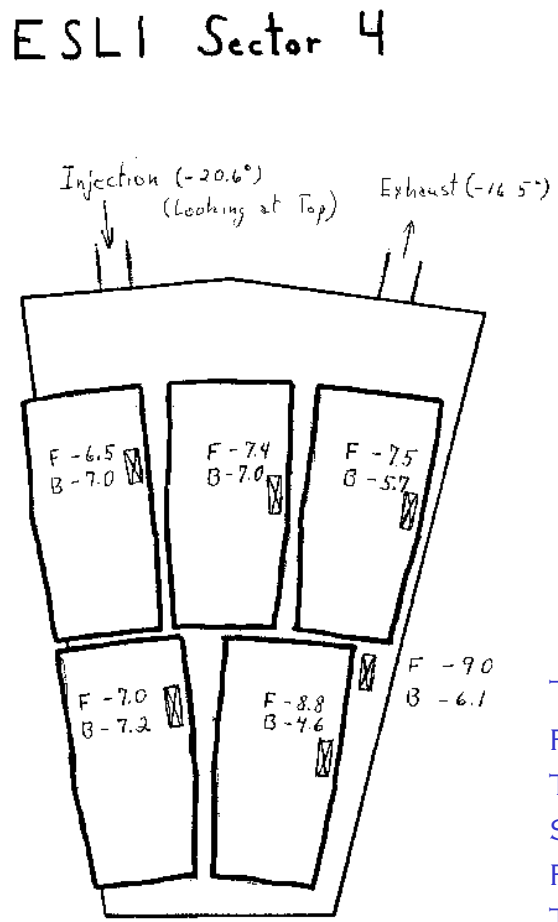
Sectors were tested in multiple orientations to see if evaporative cooling was feasible for a sector in time for the TDR.

The operating conditions here are unrealistic as the exhaust pressure is far too low (~250mBar).

Power is 40W

Pixel Detector

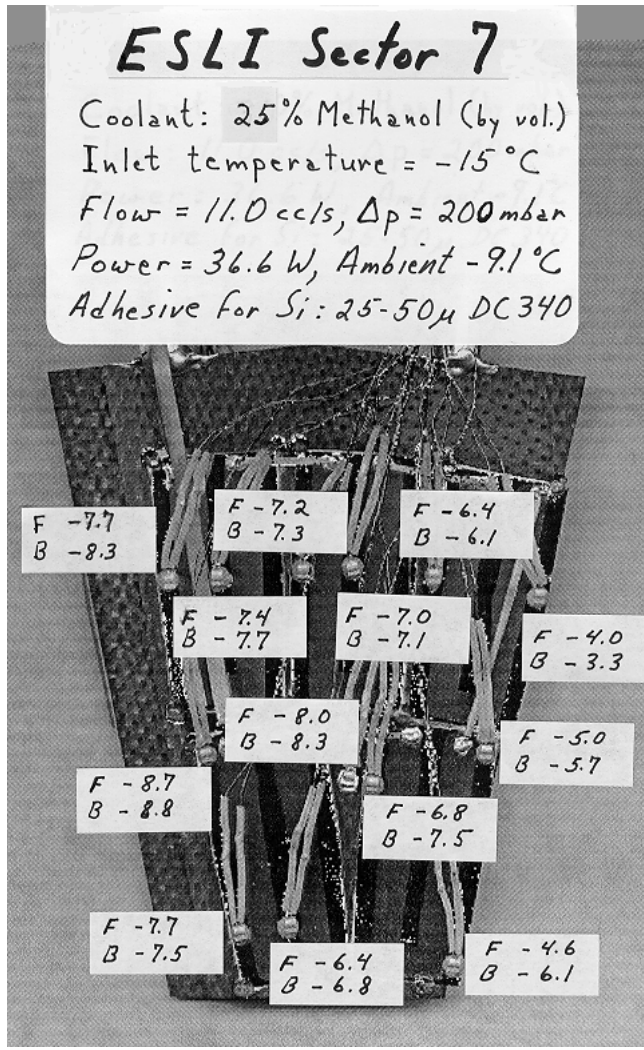
C4F10 vs. Methanol/Water



Coolant: Evaporated C_4F_{10}
Power: 36.3 W, Ambient -8/-4
Adhesive for Silicon: 125μ of CGL7018

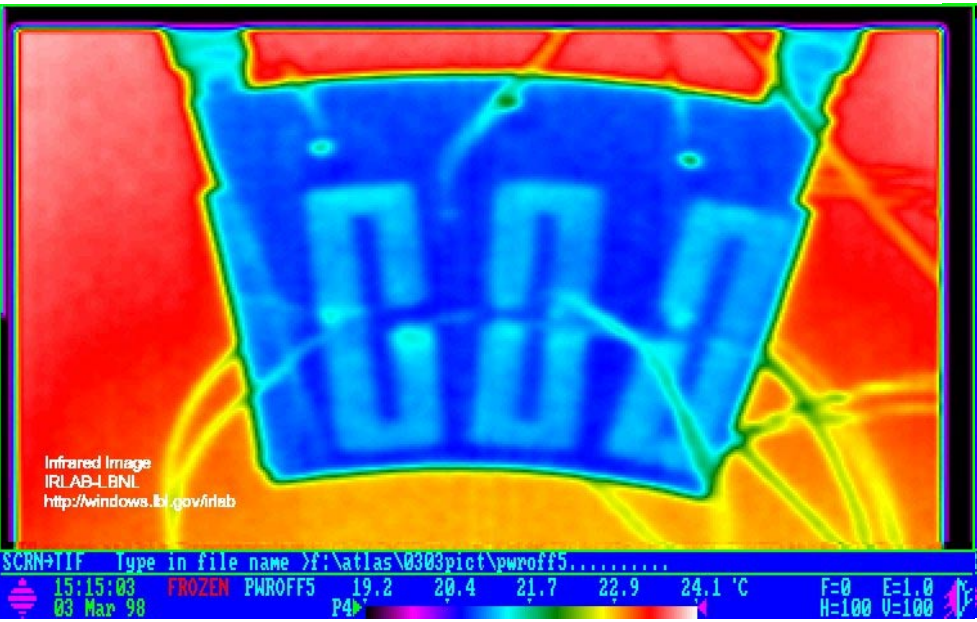
Comparison between evaporative and water cooling was made as Institutes will not all build evaporative rigs but will need to assess structures

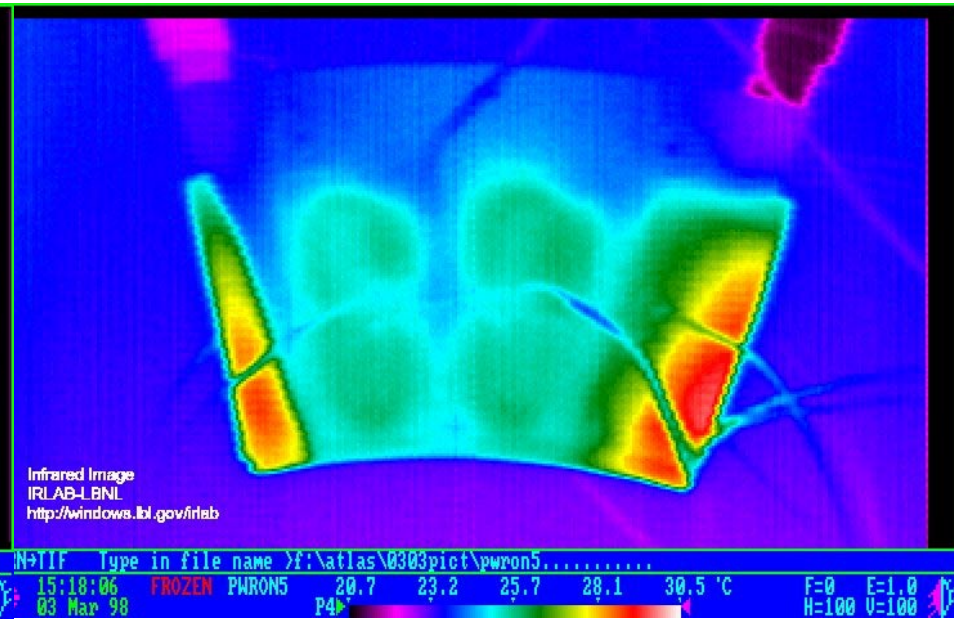
This test illustrates that a reasonable estimate of the temperatures of the structure can be made by running a fluid at close to the exhaust temperature of the evaporative system



Pixel Detector

Heat Transfer Problems





No Power condition-heater traces are seen due to difference in emissivity

Monophase flow at half required to remove heat (36W) ~5cc/sec

- **It is important to try to distinguish what is a problem with the structure from what is a problem with the cooling**
- **Monophase results, even at room temperature are useful for this.**

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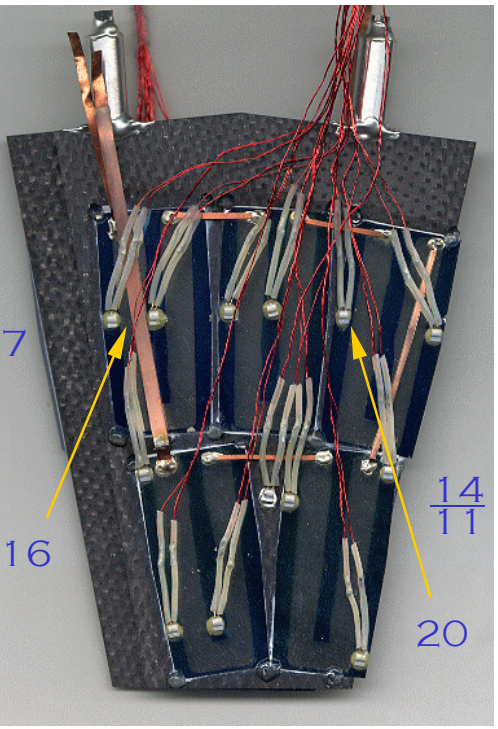
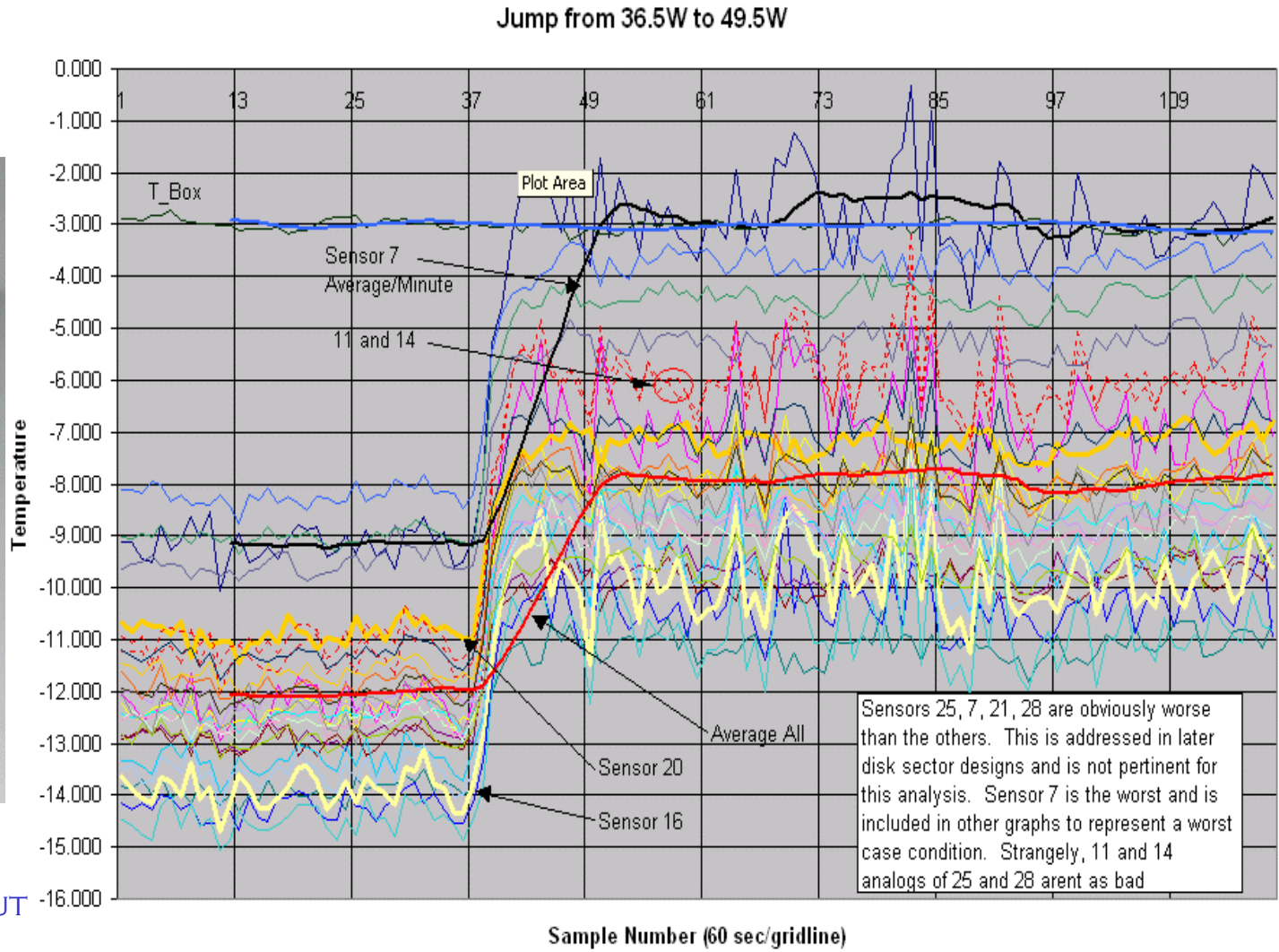
"Wings" are hard to cool

Out In



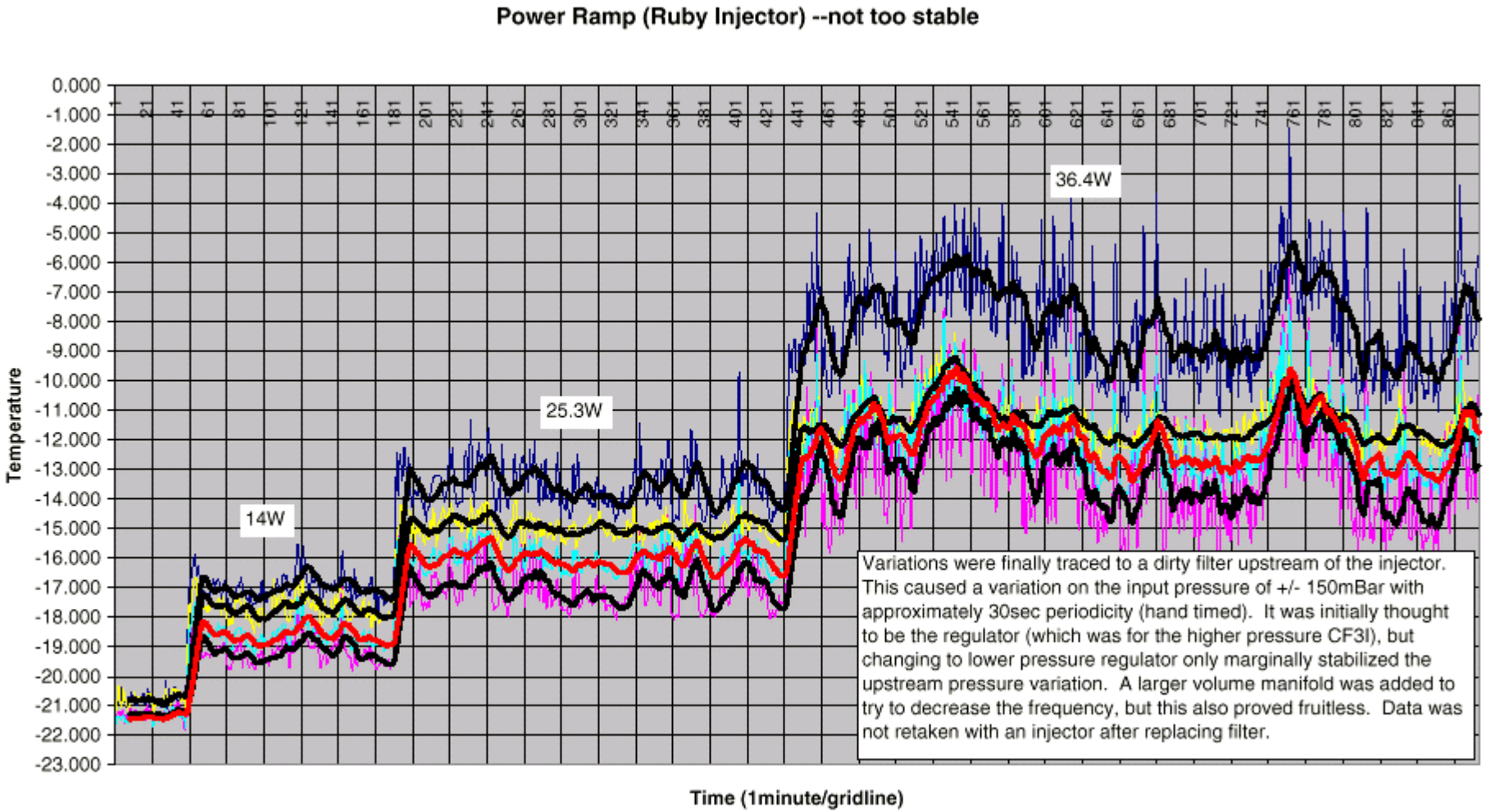


Number 7 is on back face near exhaust, but out on wing

Corollary: performance is bounded by the wings

Pixel Detector

Variability in Temperature



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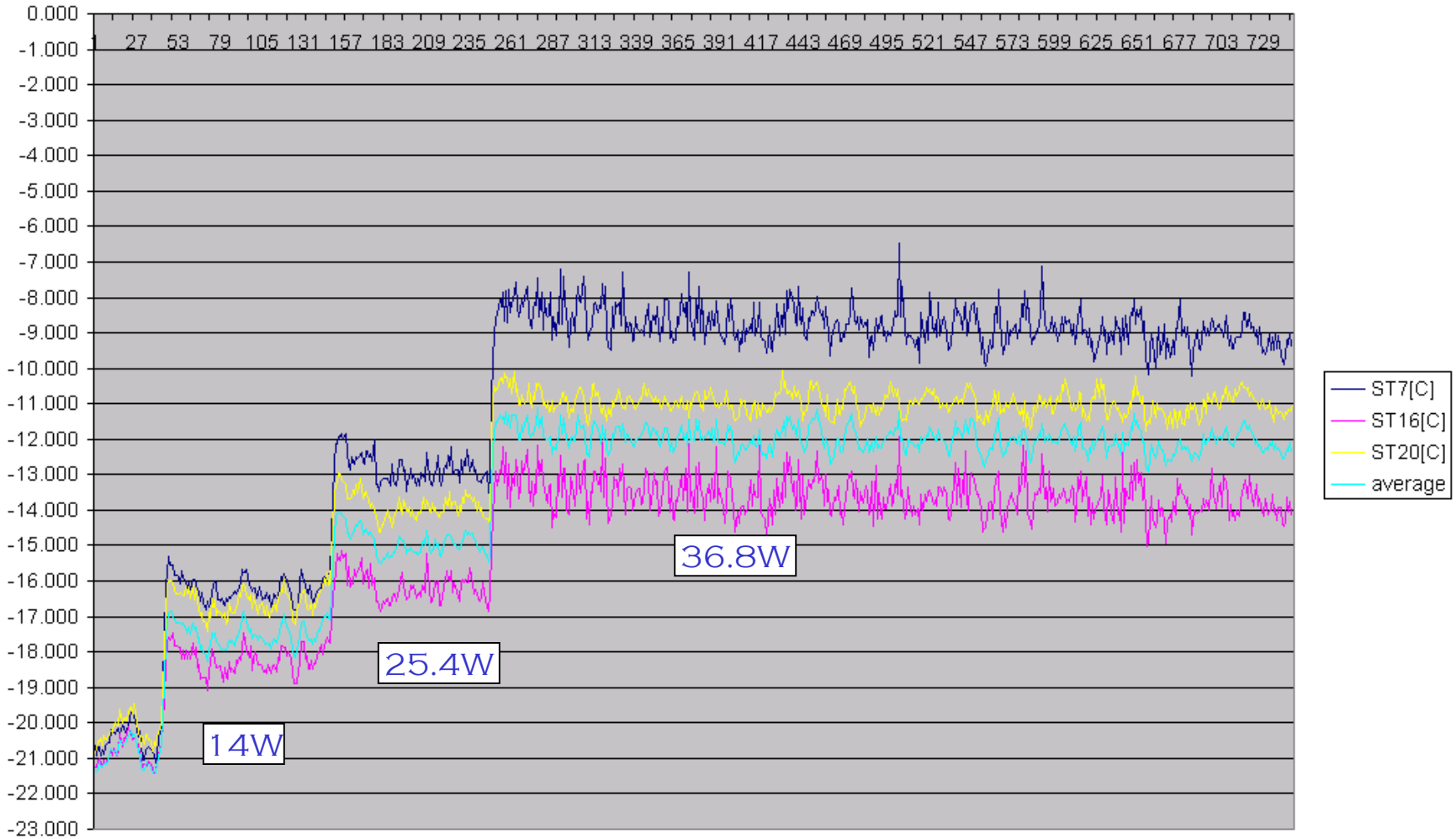
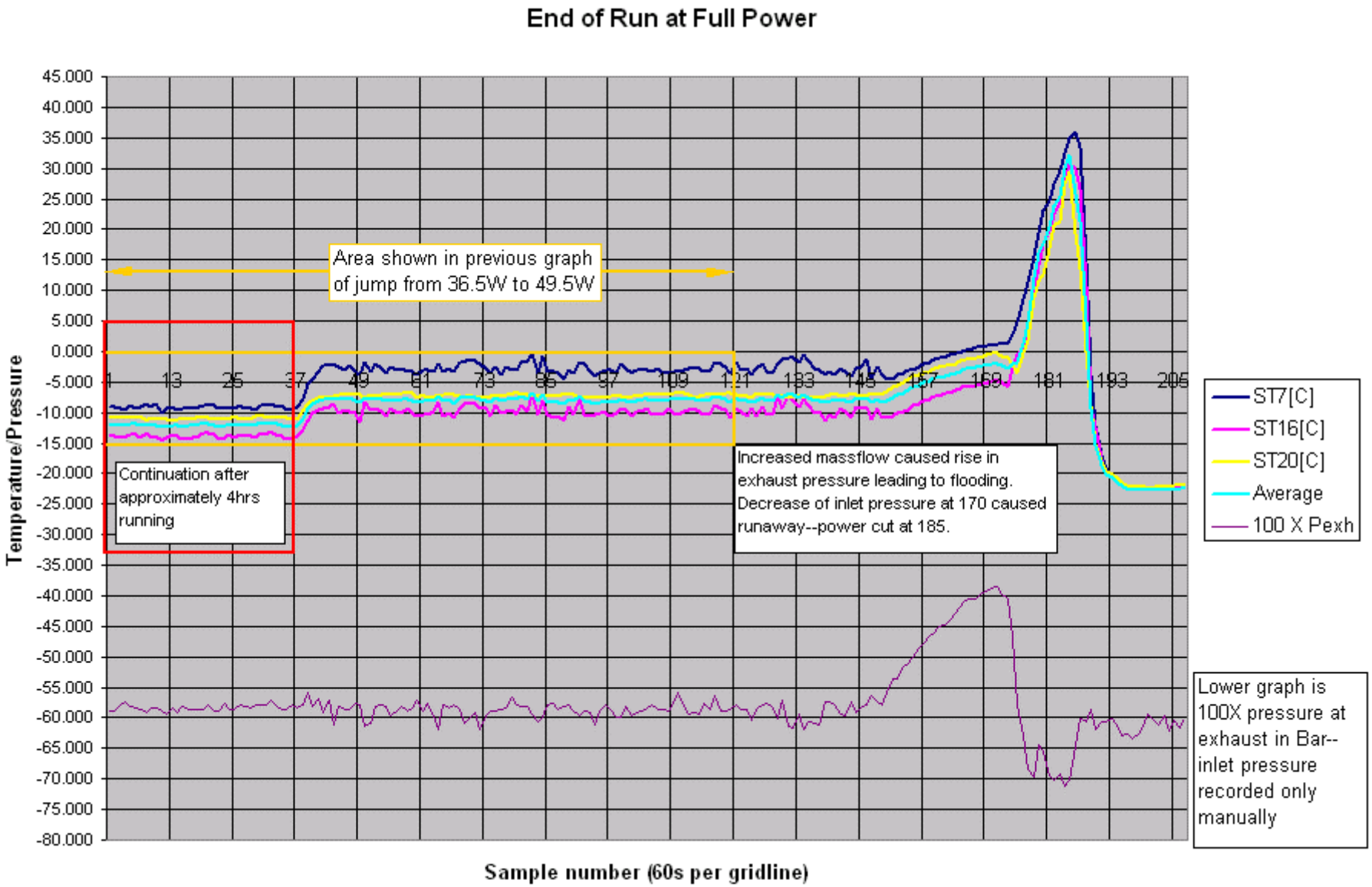
Capillary



Pixel Detector



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Runsheet Data for Disk Data Shown

Run #17

Changed to Capillary and Large volume manifold.
Fixed Box and Injector Temperature sensors
Long Run
Power at Sampletime: 13.9 @ 46
Power at Sampletime: 25.1 @ 148
Power at Sampletime: 36.7 @ 246

File name: LBL_S17.efd

Time saved:

CSV: LBL_S17.csv

Fluid: C4F10

	Pressure	Temperature
Box Environment	-	*+5.7
Upstream of injector	2.5bg +/- 0.0mb	*+13.4
Downstream of injector	-.51bg +/- 20mb	*-18.3
Exhaust	*-.60bg	*-18
Condenser	5.35babs	+16.4
Buffer	200Tabs	-

Run #18

This is an extension of run 17. Box temperature was steadily decreasing.
Recording started some 4hrs after last data taken from run 17
Long Run
Power at Sampletime: 36.5 @ 0
Power at Sampletime: 48.0 @ 44
Power at Sampletime: 49.9 @ 47
Increase P upstream ➔ 3b @134
Decrease P upstream ➔ 2.4 @ 157

File name: LBL_S18.efd

Time saved:

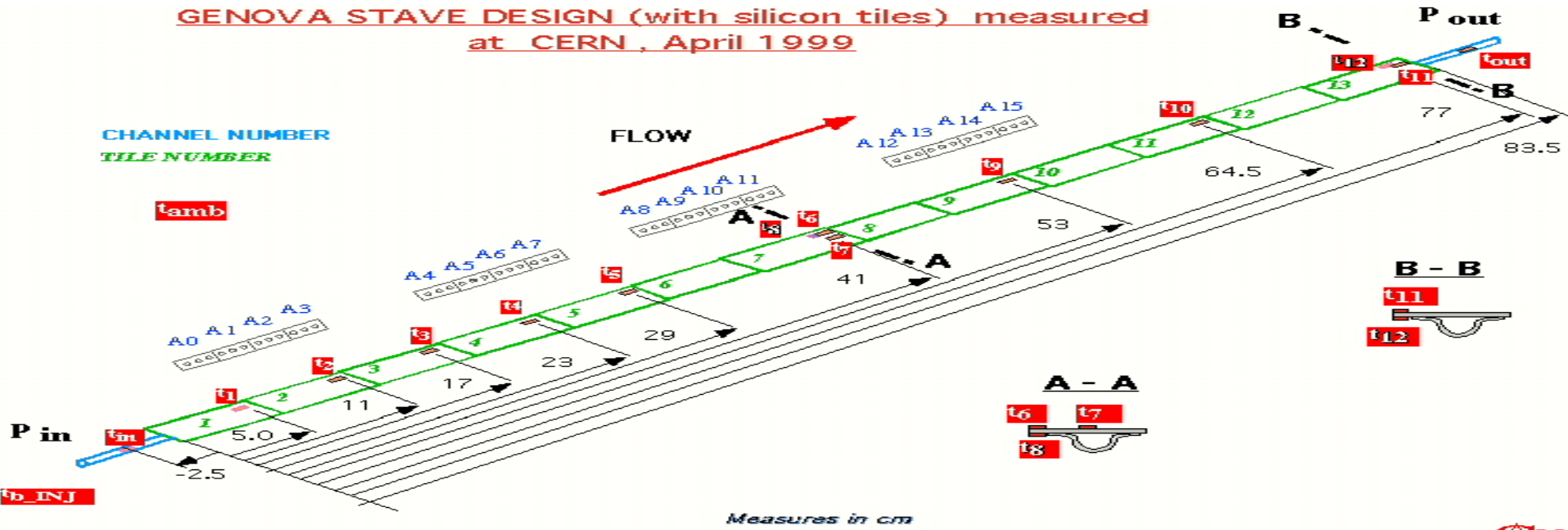
CSV: LBL_S18.csv

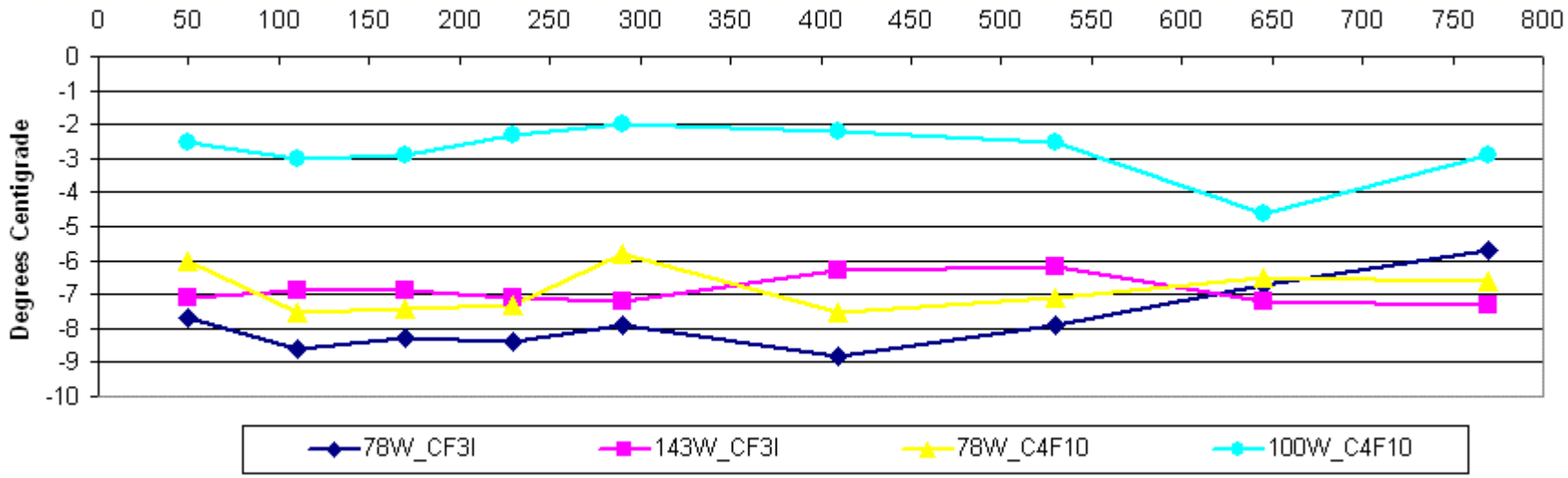
Fluid: C4F10

	Pressure	Temperature
Box Environment	-	*-3.1
Upstream of injector	2.45bg +/- 0.0mb	*+11.87
Downstream of injector	-.50bg +/- 20mb	*-18.5
Exhaust	*-.58bg	*-19.3
Condenser	5.55babs	+15.9
Buffer	200Tabs	-

This is the data for the longest run recorded. The data for the ruby injector was the same.

Pixel Detector





Conclusions

- Power increases necessitate some changes in the cooling structure, particularly the stave, but possibly the sector.
- It is not clear what portion of the pressure drop is attributable to the cooled structures and which part to the cooling setup--this must be addressed in a phase II rig
- Evaporative cooling works to Pixel specification, as apparently do capillaries
- C4F10 is possibly too low a pressure to be viable for the production rig
- CF3I looks promising thermodynamically, but has problems with compatibility
- Time constants and stability need to be better understood